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Frequency and Predictors of Left Ventricular Thrombus in Patients with Acute Anterior Wall Myocardial Infarction: A Cross-Sectional Study from a Tertiary Care Cardiac Centre in Pakistan.

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Abstract

Background: Left ventricular thrombus (LVT) is a significant complication of acute anterior wall myocardial infarction (AWMI), increasing the risk of systemic embolism, stroke, and adverse outcomes. This study aimed to determine the frequency of LVT and identify clinical predictors among patients with acute AWMI.

Methodology: An analytical cross-sectional study was conducted at the Department of Cardiology, Hayatabad Medical Complex, Peshawar, Pakistan, from July to December 2025. Ninety-one consecutive patients with acute AWMI were enrolled. Demographics, cardiovascular risk factors, ischemic time, and door-to-balloon time were recorded. Transthoracic echocardiography (TTE) was performed within 72 hours of admission to detect LVT. Associations between risk factors and LVT were analyzed using Chi-square tests, and independent predictors were identified via multivariable logistic regression. Adjusted odds ratios (aORs) with 95% confidence intervals (CIs) were reported; $p<0.05$ was considered significant.

Results: LVT was detected in 20 patients (22%). On univariate analysis, hypertension ($p=0.02$) and diabetes mellitus ($p=0.03$) were significantly associated with LVT. After adjustment, diabetes mellitus (aOR=2.59, 95% CI: 1.37–4.88, $p=0.003$), smoking (aOR=3.07, 95% CI: 1.70–5.53, $p=0.0002$), and prolonged ischemic time (aOR=1.015 per minute, 95% CI: 1.005–1.025, $p=0.0025$) emerged as independent predictors. Door-to-balloon time was not significantly associated ($p=0.11$).

Conclusion: One in five patients with acute AWMI developed LVT. Diabetes, smoking, and delayed presentation independently predict thrombus formation. These findings highlight the need for timely reperfusion, reduction of pre-hospital delays, aggressive management of modifiable risk factors, and echocardiographic screening in high-risk patients. Larger multicenter studies using advanced imaging are warranted to validate these findings and improve risk stratification.

Keywords

Left Ventricular Thrombus, Acute Anterior Wall Myocardial Infarction, Echocardiography, Ischemic Time, Diabetes Mellitus, Smoking, Cardiovascular Risk Factors.

Introduction

Cardiovascular diseases (CVDs) remain the leading cause of morbidity and mortality worldwide, accounting for a substantial proportion of premature deaths and healthcare burden. Among acute coronary syndromes, ST-segment elevation myocardial infarction (STEMI) represents one of the most severe and time-sensitive cardiovascular emergencies, requiring prompt restoration of coronary blood flow to limit myocardial damage and improve survival outcomes[1]. Over the past two decades, primary percutaneous coronary intervention (PCI) has become the preferred reperfusion strategy for STEMI because of its superiority over thrombolytic therapy in reducing mortality, reinfarction, and major adverse cardiovascular events[2].

Although successful PCI restores epicardial coronary artery patency in most patients, restoration of epicardial flow does not necessarily guarantee adequate myocardial tissue perfusion. A significant proportion of patients continue to experience impaired microvascular circulation despite angiographically successful revascularization, a phenomenon commonly referred to as microvascular obstruction or no-reflow[3]. This discrepancy highlights the importance of evaluating myocardial reperfusion at the tissue level rather than relying solely on angiographic outcomes.

ST-segment resolution (STR) measured on a standard electrocardiogram is a simple, inexpensive, and widely accepted non-invasive marker of myocardial reperfusion. Numerous studies have demonstrated that a substantial reduction in ST-segment elevation following PCI is associated with improved myocardial salvage, preserved left ventricular function, and better clinical outcomes[4,5]. Conversely, incomplete or failed STR is indicative of persistent microvascular dysfunction, distal embolization, endothelial injury, inflammatory activation, or reperfusion injury and has been consistently associated with increased risks of heart failure, ventricular arrhythmias, adverse cardiac remodeling, and mortality[6].

The pathophysiological mechanisms underlying STR failure are complex and multifactorial. Distal thrombus embolization, prolonged ischemic time, endothelial dysfunction, oxidative stress, and inflammatory responses contribute significantly to microvascular injury despite successful reopening of the culprit coronary artery[7]. Reperfusion itself may paradoxically aggravate myocardial injury through the generation of reactive oxygen species and activation of inflammatory cascades, further impairing myocardial recovery[8]. Previous studies have shown that biomarkers of oxidative stress correlate closely with impaired STR and poorer clinical outcomes following PCI[9].

Several patient-related and procedural factors have been reported as predictors of inadequate STR, including delayed symptom-to-balloon time, prolonged door-to-balloon time, anterior wall myocardial infarction, large thrombus burden, renal dysfunction, impaired left ventricular function, high Killip class, and angiographic no-reflow phenomenon[4,6,10]. These factors influence both myocardial ischemic burden and the degree of microvascular damage, thereby affecting the likelihood of achieving complete myocardial reperfusion.

The burden of ischemic heart disease is increasing rapidly in low- and middle-income countries, including Pakistan, where the prevalence of major cardiovascular risk factors such as diabetes mellitus, hypertension, smoking, obesity, and dyslipidaemia continues to rise[7,8]. Despite improvements in interventional cardiology services, outcomes following STEMI remain variable across healthcare facilities due to differences in healthcare access, treatment delays, patient characteristics, and resource availability[7-12]. Consequently, there is growing interest in identifying simple and reliable indicators that can facilitate early risk stratification after primary PCI.

Several Pakistani studies have evaluated STR as a marker of successful reperfusion and demonstrated its prognostic significance in predicting adverse cardiovascular outcomes[1,2,4,5]. Khalid et al. reported a substantial proportion of patients experiencing inadequate STR despite successful PCI[1], while Khan et al. demonstrated the complementary prognostic

value of combining STR with thrombolysis in myocardial infarction (TIMI) flow grades[4]. Similarly, Adrani et al. identified STR as an important predictor of adverse in-hospital outcomes among STEMI patients undergoing PCI[5]. However, differences in study populations, definitions of STR failure, assessment timing, and healthcare settings limit the generalizability of these findings. Hayatabad Medical Complex is one of the major tertiary cardiac care centers in Khyber Pakhtunkhwa and receives a large number of STEMI patients from both urban and rural populations. Despite the increasing utilization of primary PCI, local evidence regarding post-procedural myocardial reperfusion outcomes remains limited. Understanding the frequency of STR failure and its associated factors within this population may provide valuable insights for improving risk assessment and optimizing post-PCI management strategies.

Therefore, this study was conducted to determine the frequency of ST-segment resolution failure following primary PCI among patients with STEMI presenting to a tertiary care cardiac center in Peshawar and to evaluate its association with selected demographic and clinical characteristics. The findings may contribute to the growing body of regional evidence regarding myocardial reperfusion outcomes and support future research aimed at identifying modifiable predictors of STR failure in Pakistani patients.

Methodology

Study Design

This analytical cross-sectional study was conducted to determine the frequency of left ventricular thrombus (LVT) among patients presenting with acute anterior wall myocardial infarction (AWMI) and to identify factors associated with thrombus formation. Data were collected over a six-month period from July 2025 to December 2025. All eligible patients were assessed during their index hospitalization, and the presence or absence of LVT was determined using transthoracic echocardiography (TTE).

Ethics

Ethical approval was obtained from the Ethical and Research Committee of Hayatabad Medical Complex, Peshawar, before commencement of the study. The study was conducted in accordance with the ethical principles outlined in the Declaration of Helsinki. Written informed consent was obtained from all participants prior to enrollment. Participants were informed about the objectives, procedures, benefits, and potential risks of the study. Confidentiality and anonymity of patient information were maintained throughout data collection, analysis, and reporting.

Setting

The study was conducted in the Department of Cardiology at Hayatabad Medical Complex, Peshawar, a tertiary care referral hospital that receives patients from both urban and rural regions of Khyber Pakhtunkhwa. The hospital provides emergency cardiac care, including primary percutaneous coronary intervention (PCI), coronary care unit services, and echocardiographic assessment for acute myocardial infarction patients. All data collection and echocardiographic examinations were performed within the hospital during the study period.

Participants

Patients presenting with acute AWMI during the study period were screened consecutively for eligibility. Acute AWMI was diagnosed based on electrocardiographic evidence of ST-segment elevation of at least 1 mm in two or more contiguous precordial leads (V1–V4) together with elevated cardiac biomarkers, including troponin I (>0.04 ng/mL) or troponin T (>0.01 ng/mL). Patients aged 25–70 years of either gender were eligible for inclusion. Patients with end-stage renal disease, acute pericarditis, myocarditis, pre-existing mural thrombus, congenital cardiac abnormalities, or poor echocardiographic windows that prevented adequate visualization of the left ventricular cavity were excluded. Consecutive non-probability sampling was used, and all eligible patients presenting during the study period were invited to participate.

Variables

The primary outcome variable was the presence of left ventricular thrombus detected on transthoracic echocardiography. Independent variables included age, gender, body mass index (BMI), smoking status, hypertension, diabetes mellitus, family history of coronary artery disease (CAD), socioeconomic status, ischemic time, and door-to-balloon time. Hypertension was defined as a documented history of hypertension or blood pressure ≥140/90 mmHg measured on two separate occasions. Diabetes mellitus was defined as a previous diagnosis of diabetes, HbA1c ≥6.5%, or fasting plasma glucose ≥126 mg/dL. Smoking status was categorized as current/former smoker or never smoker. Socioeconomic status was classified into low, middle, and high categories based on monthly household income and occupation.

Data Sources / Measurement

Demographic and clinical information was collected using a structured data collection proforma completed by trained research personnel. Clinical history, cardiovascular risk factors, laboratory investigations, and treatment timelines were obtained from patient interviews and medical records. Ischemic time was calculated as the interval between symptom onset and first medical contact, whereas door-to-balloon time was measured as the duration between arrival at the emergency department and balloon inflation during primary PCI.

All participants underwent transthoracic echocardiography within 72 hours of admission using a Philips EPIQ 7C ultrasound system equipped with an S5-1 phased-array transducer (1–5 MHz). Standard parasternal long-axis, parasternal short-axis, apical four-chamber, apical two-chamber, and apical three-chamber views were acquired according to established echocardiographic guidelines. LVT was diagnosed when a discrete echodense mass distinct from the endocardial border was visualized within the left ventricular cavity and confirmed in at least two orthogonal views. Echocardiographic examinations were independently performed by two consultant cardiologists with more than five years of experience in cardiac imaging.

To ensure diagnostic consistency, echocardiographers were blinded to participants' laboratory findings and clinical risk factor profiles. Interobserver reliability was assessed by re-evaluating 20 randomly selected echocardiograms by a second cardiologist. Agreement between observers was determined using Cohen's kappa coefficient, which demonstrated excellent reproducibility ($\kappa = 0.86$).

Bias

Several measures were implemented to minimize potential sources of bias. Consecutive enrollment of eligible patients reduced selection bias. Standardized diagnostic criteria for AWMI and LVT minimized misclassification bias. Blinding of echocardiographers to patient clinical characteristics reduced observer bias. Data collection was conducted using a structured proforma to minimize information bias. However, recall bias may have occurred when recording symptom onset time for ischemic time calculation. In addition, because cardiac magnetic resonance imaging (CMR), the reference standard for LVT detection, was unavailable, TTE was used as the sole imaging modality, which may have resulted in under-detection of small or apical thrombi.

Study Size

The required sample size was calculated using the World Health Organization sample size formula for prevalence studies. Assuming a prevalence of LVT of 18.39% among patients with acute AWMI as reported previously [5], a confidence level of 95%, and an absolute precision of 8%, the minimum required sample size was calculated to be 91 participants. A total of 91 eligible patients were successfully enrolled during the study period.

Quantitative Variables

Age, BMI, ischemic time, and door-to-balloon time were treated as continuous variables. Continuous variables were assessed for normality using the Shapiro–Wilk test before statistical analysis. Normally distributed variables were expressed as mean ± standard deviation, while non-normally distributed variables were summarized using median and interquartile range. Categorical variables were reported as frequencies and percentages.

Statistical Methods

Data were entered and analyzed using Statistical Package for Social Sciences (SPSS) version 21. Descriptive statistics were used to summarize demographic, clinical, and echocardiographic characteristics of the study population. Frequencies and percentages were calculated for categorical variables, while means with standard deviations or medians with interquartile ranges were reported for continuous variables as appropriate.

Associations between categorical variables and the presence of LVT were assessed using Chi-square tests or Fisher's exact test when expected cell counts were less than five. Stratified analyses were performed to assess the potential modifying effects of age, BMI, smoking status, hypertension, diabetes mellitus, and socioeconomic status. Variables considered clinically relevant or statistically significant in univariate analyses were included in a multivariable logistic regression model to identify independent predictors of LVT. The regression model included diabetes mellitus, smoking status, ischemic time, and door-to-balloon time, while adjusting for age, gender, BMI, hypertension, and socioeconomic status. Results were reported as adjusted odds ratios (aORs) with 95% confidence intervals (CIs). A two-sided p-value of less than 0.05 was considered statistically significant.

Results

Participants

A total of 91 patients diagnosed with acute anterior wall myocardial infarction (AWMI) were enrolled during the study period and included in the final analysis. All eligible patients completed the study assessments and underwent transthoracic echocardiography (TTE) for evaluation of left ventricular thrombus (LVT). There were no exclusions after enrollment, and complete clinical and echocardiographic data were available for all participants. The study population comprised patients presenting to the Cardiology Department of Hayatabad Medical Complex, Peshawar, during their index hospitalization for AWMI.

Descriptive Data

The baseline demographic characteristics of the study population are summarized in Table 1. Of the 91 participants, 45 (49.5%) were male and 46 (50.5%) were female, indicating a nearly equal gender distribution. The mean age of the participants was 47.8 ± 12.6 years, with ages ranging from 25 to 70 years. Regarding residential status, 50 patients (54.9%) were from urban areas, whereas 41 patients (45.1%) resided in rural settings. Socioeconomic assessment revealed that 28 participants (30.8%) belonged to the low socioeconomic group, 41 (45.1%) to the middle socioeconomic group, and 22 (24.2%) to the high socioeconomic group. These findings indicate that the study population represented a diverse demographic and socioeconomic spectrum of patients presenting with acute AWMI (Table 1).

Clinical risk factors evaluated during the study included smoking status, hypertension, diabetes mellitus, family history of coronary artery disease (CAD), ischemic time, and door-to-balloon time. These variables were further analyzed to determine their relationship with the development of LVT.

Outcome Data

The primary outcome of the study was the presence of left ventricular thrombus detected by transthoracic echocardiography. LVT was identified in 20 out of 91 patients, resulting in an overall frequency of 22.0%, while the remaining 71 patients (78.0%) showed no evidence of thrombus formation (Table 2). This finding demonstrates that approximately one in every five patients presenting with acute AWMI developed LVT during the early post-infarction period.

The observed frequency is clinically important because LVT represents a significant source of thromboembolic complications following myocardial infarction. The distribution of patients according to LVT status is presented in Table 2.

Main results

Bivariate analyses were performed to evaluate the association between selected clinical risk factors and the occurrence of LVT. No statistically significant association was observed between

gender and LVT development (χ^2 = 1.32, p = 0.251), as illustrated in Figure 1. Similarly, smoking status was not significantly associated with LVT on unadjusted analysis (χ^2 = 0.85, p = 0.356), as shown in Figure 2.

In contrast, hypertension demonstrated a statistically significant association with LVT occurrence (χ^2 = 5.41, p = 0.02). Among hypertensive patients, a greater proportion developed LVT compared with non-hypertensive individuals. Likewise, diabetes mellitus was significantly associated with thrombus formation (χ^2 = 4.70, p = 0.03). Among diabetic patients, 35.0% developed LVT, whereas only 18.3% of non-diabetic patients experienced thrombus formation, indicating a substantially higher burden among individuals with diabetes. Family history of coronary artery disease was not significantly associated with LVT occurrence (χ^2 = 0.58, p = 0.447). To identify independent predictors of LVT, a multivariable logistic regression model was constructed after adjustment for potential confounders, including age, gender, body mass index (BMI), hypertension, and socioeconomic status. The results of the regression analysis are presented in Table 3. After adjustment, diabetes mellitus remained a significant independent predictor of LVT (adjusted odds ratio [aOR] = 2.59, 95% CI: 1.37–4.88, p = 0.003). Patients with diabetes had approximately 2.6 times greater odds of developing LVT compared with non-diabetic patients. Smoking also emerged as an independent predictor after adjustment (aOR = 3.07, 95% CI: 1.70–5.53, p = 0.0002), indicating that smokers had approximately three times higher odds of LVT than non-smokers. Furthermore, ischemic time demonstrated a significant positive association with LVT formation (aOR = 1.015 per minute increase, 95% CI: 1.005–1.025, p = 0.0025). This finding suggests that prolonged delays between symptom onset and first medical contact increase the likelihood of thrombus formation following AWMI. Conversely, door-to-balloon time did not show a statistically significant association with LVT after adjustment (aOR = 1.008, 95% CI: 0.998–1.018, p = 0.11).

Overall, the multivariable analysis demonstrated that diabetes mellitus, smoking, and prolonged ischemic time were the strongest independent predictors of LVT in patients with acute AWMI (Table 3). These findings highlight the importance of prompt medical attention following symptom onset and aggressive management of modifiable cardiovascular risk factors to reduce the burden of thrombotic complications after myocardial infarction.

Table 1: Demographic Characteristics of the Study Population (N=91).

Variables	**N(%)**
Gender	
Male	45 (49.5)
Female	46 (50.5)
Age (years); Mean ± SD	47.8 ± 12.6
Residence	
Urban	50 (54.9)
Rural	41 (45.1)
Socio-economic Status	
Low	28 (30.8)
Middle	41 (45.1)
High	22 (24.2)

Table 2: Frequency of Left Ventricular Thrombus (LVT) in Acute AWMI Patients.

LVT	N(%)
Yes	20 (22.0%)
No	71 (78.0%)

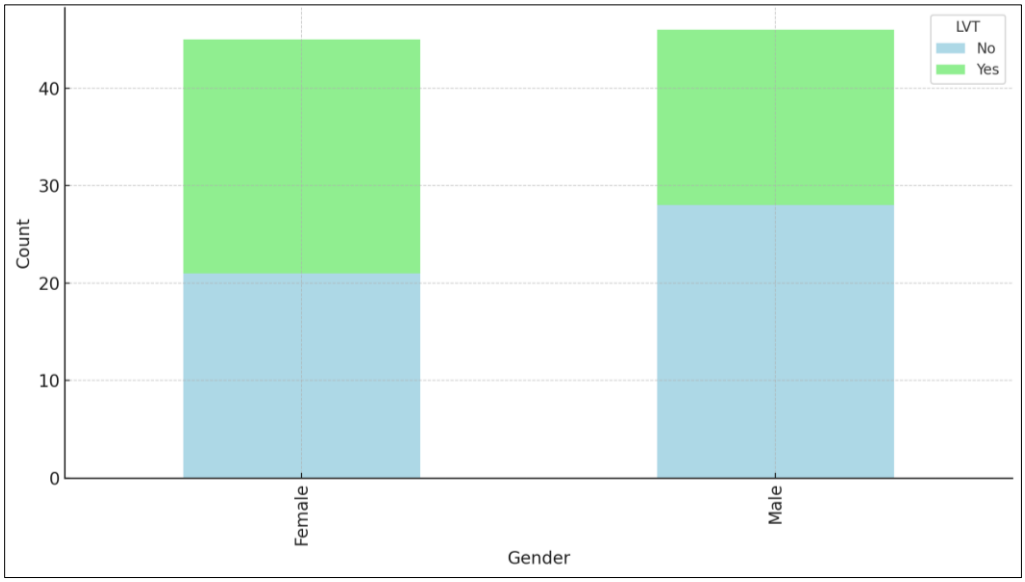

Figure 1: Gender and LVT association (χ^2, p = 0.251).

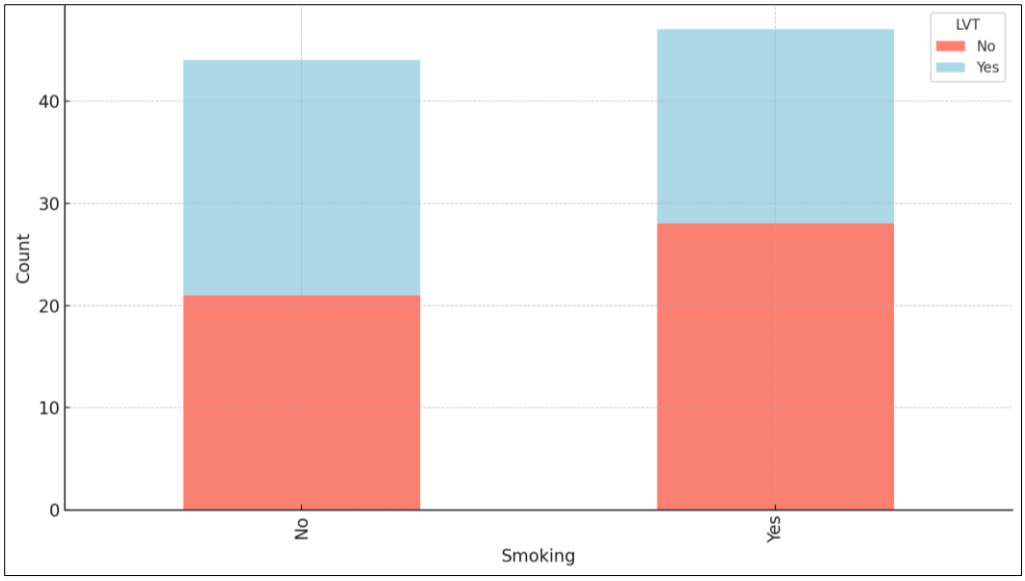

Figure 2: Smoking and LVT association (χ^2, p = 0.356).

Table 3: Multivariable Logistic Regression – Independent Predictors of LVT.

Variables	Adjusted Odds Ratio (aOR)	95% CI	p-value
Diabetes (yes vs. no)	2.59	1.37 – 4.88	0.003*
Smoking (yes vs. no)	3.07	1.70 – 5.53	0.000*
Ischemic time (per minute)	1.015	1.005 – 1.025	0.002*
Door-to-balloon time (per minute)	1.008	0.998 – 1.018	0.110

Discussion

The present study evaluated the frequency of left ventricular thrombus (LVT) among patients presenting with acute anterior wall myocardial infarction (AWMI) and identified factors associated with thrombus formation in a tertiary care cardiac center in Pakistan. The findings revealed that LVT was present in 22.0% of patients, indicating that approximately one in every five individuals with AWMI developed this potentially serious complication. Furthermore, multivariable analysis demonstrated that diabetes mellitus, smoking, and prolonged ischemic time were independent predictors of LVT development. These findings highlight the continued clinical importance of LVT despite advances in contemporary reperfusion strategies and cardiovascular care.

The observed frequency of LVT is consistent with previously published national and international literature. The prevalence reported in the current study closely resembles findings from Lahore (18.39%) and Karachi (15.8%)[4,5], while remaining within the broader international range of 5%–38% reported among patients with acute myocardial infarction[2]. Variations across studies may be explained by differences in study design, patient characteristics, infarct severity, timing of echocardiographic evaluation, availability of reperfusion therapy, and imaging modalities used for diagnosis. Studies utilizing cardiac magnetic resonance imaging (CMR) generally report higher frequencies because of superior sensitivity for detecting small or mural thrombi compared with transthoracic echocardiography (TTE)[8].

One of the most important findings of this study was the independent association between diabetes mellitus and LVT formation. Patients with diabetes had more than twice the odds of developing LVT compared with non-diabetic patients. This observation is biologically plausible because diabetes promotes endothelial dysfunction, platelet activation, chronic inflammation, oxidative stress, and a prothrombotic state, all of which contribute to intracardiac thrombus formation[14,15]. In addition, diabetic patients often experience more extensive coronary artery disease, larger infarct size, impaired microvascular perfusion, and delayed myocardial recovery, thereby increasing the risk of ventricular thrombus formation following myocardial infarction. Smoking was also identified as a strong independent predictor of LVT after adjustment for confounding variables. Although smoking did not demonstrate a significant association in the unadjusted analysis, its effect became apparent following multivariable adjustment. This finding suggests the presence of confounding factors that masked the true association in the bivariate analysis. Smoking has been extensively linked to endothelial injury, enhanced platelet aggregation, increased fibrinogen levels, and hypercoagulability, all of which contribute to thrombogenesis[14]. The approximately three-fold increase in LVT risk observed among smokers in the present study underscores the importance of smoking cessation as a critical component of post-myocardial infarction management.

Another notable finding was the significant relationship between ischemic time and LVT development. Each incremental increase in ischemic time was associated with a corresponding increase in the likelihood of thrombus formation. Delayed restoration of coronary blood flow leads to prolonged myocardial ischemia, greater infarct size, more extensive ventricular remodeling, and increased regional wall motion abnormalities, thereby creating favorable conditions for blood stasis and thrombus formation[2,15]. This observation has important clinical implications because ischemic time

is a potentially modifiable factor. Efforts aimed at improving public awareness of myocardial infarction symptoms, enhancing emergency medical services, and reducing delays in seeking medical care may contribute to lowering the burden of LVT.

In contrast, door-to-balloon time did not emerge as a statistically significant predictor of LVT. This finding may be attributable to relatively uniform in-hospital management and timely primary percutaneous coronary intervention among the study population, limiting variability in this parameter. Alternatively, the modest sample size may have reduced the statistical power to detect a significant association. Larger studies are required to clarify the role of door-to-balloon time in LVT development.

Although hypertension demonstrated a significant association with LVT during bivariate analysis, this relationship was not retained after adjustment for confounding factors. Similar findings have been reported in previous studies, where hypertension appeared to act indirectly through its association with other cardiovascular risk factors rather than serving as an independent determinant of thrombus formation[14]. Likewise, family history of coronary artery disease was not significantly associated with LVT in the present study.

The findings of this study have important clinical implications for risk stratification and management of patients with AWMI. Given the relatively high frequency of LVT observed, routine echocardiographic screening should be considered, particularly among patients with diabetes, smoking history, or delayed presentation after symptom onset. Early identification of LVT facilitates timely initiation of anticoagulation therapy, which may reduce the risk of systemic embolization, ischemic stroke, and other thromboembolic complications[10–12]. In resource-limited settings where advanced imaging modalities are unavailable, careful clinical risk assessment combined with echocardiographic surveillance may represent a practical approach for improving patient outcomes.

A notable strength of this study is the inclusion of clinically relevant variables such as ischemic time and the use of multivariable logistic regression to identify independent predictors of LVT. Furthermore, standardized echocardiographic protocols and blinded image interpretation enhanced the reliability of LVT diagnosis. The study also contributes valuable local evidence from Khyber Pakhtunkhwa, where published data on LVT following AWMI remain limited.

Limitations

Several limitations should be considered when interpreting the findings of this study. First, the study was conducted at a single tertiary care center, which may limit the generalizability of the results to other populations and healthcare settings. Second, the sample size was relatively small, particularly for multivariable regression analysis. Although adequate for estimating prevalence, the limited number of LVT-positive events may have increased the risk of model overfitting and reduced the precision of adjusted effect estimates. Third, transthoracic echocardiography was used as the sole imaging modality for LVT detection. While TTE is widely available and clinically useful, it is less sensitive than cardiac magnetic resonance imaging, particularly for identifying small, mural, or apical thrombi [8]. Consequently, the true prevalence of LVT may have been underestimated. Fourth, left ventricular ejection fraction (LVEF), a well-established predictor of LVT, was not systematically measured and therefore could not be incorporated into the analysis. The absence of LVEF data may have resulted in residual confounding. Fifth, ischemic time was partly dependent on patient-reported symptom onset and may therefore be subject to recall bias. Sixth, the cross-sectional nature of the study precludes causal inference between identified risk factors and thrombus formation. Finally, long-term follow-up data regarding thromboembolic events, stroke, recurrent myocardial infarction, bleeding complications, and mortality were not available. Consequently, the prognostic significance of LVT detected in this cohort could not be assessed. Future multicenter studies incorporating larger sample sizes, systematic assessment of left ventricular function, advanced imaging techniques such as CMR, and longitudinal follow-up are required to validate these findings and further refine risk

prediction models for LVT in patients with acute myocardial infarction.

Conclusion

Left ventricular thrombus remains a common and clinically important complication among patients with acute anterior wall myocardial infarction. In the present study, LVT was identified in 22.0% of patients, demonstrating a substantial burden of disease despite contemporary cardiac care. Diabetes mellitus, smoking, and prolonged ischemic time emerged as independent predictors of thrombus formation, highlighting the importance of both biological and healthcare-system-related determinants of risk.

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